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ON A UNIVERSAL INDICATOR FOR MICROSCOPES.

In the Quarterly Journal of Microscopical Science, vol. i, p. 34, an ingenious contrivance for registering the position of microscopic objects is described by Mr. Tyrrel; a modification of this, by Mr. Aymot is given in a subsequent number (l. c., vol. i, p. 301); and a still better arrangement for the same purpose, suggested by Mr. Brodie and applied by Mr. Okeden to his microscope, is described at p. 166 of volume iii. of the same work. The last mentioned device can scarcely be improved upon for convenience; but there is one defect which is inherent to all these inventions, viz: that they are essentially selfish contrivances, of no use to any one but the owner of the particular instrument to which they may be attached.

The object of the instrument I propose is more comprehensive than that of the "Finders" above alluded to; being no less than to make a Universal Indicator by means of which an observer can so register the position of any number of objects mounted upon slides, that when these are sent to a distant correspondent the latter may be able by means of the Indicator to find at will any of these objects as easily as if he had the identical microscope and "Finder" by which they were at first recorded. If such a mode of recording the position of objects can be generally adopted that when the register is once made, the record and the objects shall then be entirely independent of the original instrument and observer, and applicable to any microscope, it will tend to promote science not only by facilitating the interchange of specimens among naturalists, but it will give to each observer's collection when properly registered, a permanent scientific value and utility which it could have in no other manner.

The plan I have adopted is to make upon an engraved card what may be considered as a transferable stage having guide lines by means of which the centre of the field of view of the microscope, and the position of a slide when any object upon it occupies this centre, may be given.

Plate I. shows the Indicator complete. The centre of the field of view corresponds to the intersection of the horizontal line C, D, with the vertical line E, F. On the right and left hand of this centre the vertical axes B, and A′, are placed at distances of $\frac{4}{5}$ths

of an inch, and the axes A, and B′ are similarly placed at the distances of $\frac{6}{5}$ths of an inch from the centre.

The axes are then graduated as seen in the plate; the small divisions being each $\frac{1}{50}$th of the standard inch.

The dotted lines G, H, I, give the outline of what will be referred to as the *centre piece.*

Should it ever be desired to reproduce the Indicator by engraving or otherwise, the dimensions above given must be most accurately preserved. The dimensions here given were taken from the standard inch of the United States belonging to the State of New York and preserved in the office of the Superintendent of Weights and Measures in Albany. It is the same as the English inch.

The slides on which objects are mounted to be used with the Indicator must have *guide-lines* ruled on their *under side* as shown in fig. 1 and 2. The horizontal line parallel to the lower edge and passing through the middle of the slide is not continued over the portion of the slide which is to be occupied by the objects and their glass cover. The distance of each of the vertical lines from the middle point of the slide is *one inch.* Great accuracy in the distance between these lines of the slide is not essential when they are to be used with the ordinary form of the Indicator as above given, but it is desirable when they are to be employed as hereafter described with a modification of the Indicator applied to a moveable stage.

The slides should all be marked with an arrow placed upon their upper and right hand corner, as shown in fig. 1 and 2, to point out the edge which must always be kept in front in using the slides upon the Indicator.

The Indicator is to be used as follows:—Cut out the centre piece with a thin bladed knife following the outline G, H, I; then replace the piece cut out, and make a hinge for it along the line G, H, by pasting underneath it a piece of thin paper which will bear repeated folding, so as to connect it to the rest of the card.

The Indicator being now ready for use, it must be firmly secured to the stage of the microscope in such a position that its centre as given by the intersection of the lines C, D, and E, F, when viewed as an opaque object, may be exactly in the centre of the field of view. If the stage is a moveable one, it must be kept stationary after the Indicator is properly centred.

The Indicator having been adjusted as above directed, the centre piece is to be turned down and the instrument is then ready for use, either to record new objects, or to find those previously recorded. The slide is to be put upon the Indicator, and guided either by the fingers or a moveable ruler so that when any object which is to be registered occupies the centre of the field of the microscope, the horizontal guide line upon the slides shall pass

through the same numbers on two vertical axes of the Indicator as remote from each other as possible. In some positions of the slide the axes A, and B′ can be used for this purpose; in others A, and A′, or B, and B′ must be employed.

The horizontal line of the slide being arranged as just directed it will be found that at least one of the vertical guide lines of the slide will intersect the horizontal graduation. By observing now the numbers at which the guide lines respectively stand, the record can be made. Suppose for example that the horizontal guide line ruled upon the slide intersects the verticals of the Indicator at 43, while the right hand vertical of the slide cuts the horizontal series of numbers of the Indicator at 75; the entry to be made for this object in the register would be written thus $\frac{4}{7}\frac{3}{5}'$ and whenever that particular object is to be found either by the same Indicator or *any other copy of it*, if the slide is placed at these numbers and the Indicator is properly centred, the object must be in the field of view. In the same manner any number of objects can be registered or found. If the slide happens to be so placed that both of its verticals intersect the graduated portions of the horizontal line C, D, the position of either one of them can be recorded at will.

If a guide line upon the slide falls between two divisions of either scale, the fraction of the division may be estimated with sufficient accuracy by the eye or a hand magnifier and entered in the register. Thus the recorded position $\frac{25\frac{1}{8}'}{34\frac{1}{4}'}$ would mean that the vertical lines of the Indicator were intersected at $\frac{1}{8}$th of a division of the scale beyond 25, while the vertical guide line of the slide passed $\frac{1}{4}$th of a division beyond the number 34 of the horizontal scale, as nearly as could be estimated.

It is convenient to let the lower edge of the glass slide rest against a straight edged guide piece which can be moved parallel to the horizontal line of the Indicator. By pushing the slide along this edge, all the objects on the same horizontal can be found without changing the position of the guide piece. By moving the guide piece a little forward or back another sweep across the slide may be made, and so on until every object of interest is found.

By following the directions above given it will be found that the recording or finding of objects by means of the Indicator is very easily performed, and scarcely requires the time which has been employed in describing the method. It is believed that the explanation above given is sufficiently explicit to enable any one to use the Indicator; but some additional remarks will now be made upon the reasons for adopting the particular arrangement I have used, the modes of insuring accuracy in manipulation, and the modifications of which the Indicator is susceptible for individual convenience.

It was desired to make the instrument capable of universal application; so simple that it could be adapted to any stage; so light and yet so strong that it could be sent without injury by mail or otherwise to any distance; and lastly that the different copies should be perfect fac-similes of each other and reproducible at any time. All this is secured by having the Indicator engraved upon a steel plate and printed upon cards of uniform quality, and by taking the dimensions from the standard United States inch, preserved in the office of the Superintendent of Weights and Measures in Albany. In order to extend the use of the Indicator to all cases which are likely to occur, the graduation was arranged with reference to slides three inches long and one inch wide, while it will answer equally well for smaller ones. When these slides are not covered with paper, and guide lines can be ruled as above directed upon the glass itself, the graduations necessary for their use would only extend upon the verticals $\frac{1}{2}$ an inch above and below the horizontal line, and upon the horizontal line only $\frac{1}{2}$ an inch outwards from the points 40 and 70; but in order to provide for paper covered, or opaque slides whose uppermost and lateral edges may be used as guide lines, the graduation has been extended considerably. It will be found on trial that slides of the standard size, whether paper covered or not, may be employed with the Indicator for the registration of all objects under a glass cover of a square inch in size, which is quite as large as is likely to be used. In using covering glasses of an inch square it will be found necessary to employ the horizontal numbers 0 to 50, and the verticals A, A′, for objects towards the right of the cover, and the other axes and numbers for objects towards the left. For a portion of the objects under the cover either set of axes and numbers may be used at pleasure provided that the verticals are chosen as far apart as possible.

Two verticals on the same side of the centre should never be used together, as a small error in observing the numbers would have more effect in displacing the object from the centre than if two axes at a greater distance had been employed. The reason for leaving a blank ungraduated space between 50 and 60 on the horizontal line was to allow a fac-simile of the Indicator to be engraved upon the stage of any microscope, the blank space being left for the portion of the stage occupied by the aperture.

The guide lines upon the glass may be ruled with a fine pointed scratching diamond, and be rendered more visible by having graphite or black lead rubbed into them. Lines ruled in this manner will answer for all except very minute objects, but in consequence of the widening of the lines by the chipping up of the glass due to unequal expansions and contractions, the lines often become too wide and irregular for very accurate adjustments. In such cases admirable guide lines may be etched upon the glass

with the *vapor* of fluohydric acid and can be made of any required degree of fineness. The *solution* of the acid should not be employed for the etching as it gives lines which are too smooth and difficult to see, and which will not retain the black lead if rubbed into them.

The power of the objective employed in determining the position of an object for registration, should always be the highest which can be conveniently employed; while in searching for an object already recorded, a power lower than that employed in the registration may be used. The object then must be in the field of view, and would be at the centre but for slight errors in manipulation, or the want of perfect adjustment in the mountings of the object-glass. Care should be taken to bring each object accurately to the centre of the field of view, before recording it. It will then require an error equal to half the diameter of the field of view to throw it out of that field. For example the field of view of my ½ inch objective made by Spencer, includes two divisions of the Indicator, and hence an error of nearly one division might be made in placing a slide upon the Indicator by means of its recorded numbers and yet the object would be found in the field.

It may happen that in transferring a slide from one Indicator to another that the object when brought into sight by means of its recorded co-ordinates will not appear well centred. If this be due to slight differences in determining the centres of the Indicator, and yet the record has been carefully made, it is easy to correct for the difference in the following manner. Move the Indicator *with* the slide placed at any recorded position until the object comes into the centre of the field of view, then secure the Indicator to the stage in this new position, and all other objects recorded by the same Indicator ought to be brought to the centre of the field of view by means of the numbers as registered.

The convenience of the Indicator for individual use may be increased by several slight changes. One of these consists in removing the paper centre piece, and replacing it either temporarily or permanently by a glass plate bearing lines at right angles to each other ruled very lightly with a diamond point, and so adjusted as to coincide with the prolongation of C D and E F through the centre. For all but the highest powers there is no objection to having these excessively minute lines permanently beneath the centre of the Indicator as they do not perceptibly interfere with the light, and it is convenient to have them always in place. They can be ruled upon a piece of mica or thin glass cemented to the back of the Indicator, or the latter may itself be cemented to a piece of plate glass and the central guide lines then carefully ruled. Even for the highest powers these lines can be used in recording the position of objects, which can then be found for

study by using an Indicator of the ordinary form. By a proper arrangement, a moveable stage, with screws for vertical and horizontal motions, may be gradnated so as to correspond to the Indicator, and yet preserve all the advantages of accurate adjustment which the screws afford. For this purpose it is necessary to observe that if the Indicator be placed upon the stage and accurately centred, with its guide line C, D, parallel to the front edge of the stage, and a slide be then placed upon the Indicator so that its horizontal guide line shall coincide with C, D, and the right hand vertical guide line stand at 70, (*i. e.* in the position which would be recorded as $\frac{5}{7}\frac{0}{0}'$,) or its left hand guide line at $\frac{5}{4}\frac{c}{0}'$; then a motion of the stage itself bearing with it the Indicator and slide, or an equal motion of the slide upon the Indicator and fixed stage will bring the same point of the slide to the centre of the field of view.

Therefore by attaching to the stage in any convenient manner gradnations corresponding to those of the Indicator, and by having lines corresponding to $\frac{5}{7}\frac{0}{0}'$ and $\frac{5}{4}\frac{c}{0}'$ ruled upon the stage, it will only be necessary to place the slide directly on the stage at these numbers, the stage itself being set either at $\frac{5}{7}\frac{0}{0}'$ or $\frac{5}{4}\frac{0}{0}'$ of its gradnations. By turning the milled heads of the screws which give the vertical and horizontal motions of the stage, the object can be brought into the field of view and recorded or found again by means of the numbers attached to the stage ; while the record may be nsed for any other Indicator as if made in the usnal manner. If the distance between the guide lines upon the slide agrees accurately with that between 40 and 70 of the Indicator, the slide when placed upon the moveable stage at either $\frac{5}{4}\frac{0}{0}'$ or $\frac{5}{7}\frac{0}{0}'$ will need no displacement for the whole series of numbers ; but if this distance does not agree; the slide must be put with its left hand vertical coinciding with the left hand vertical of the stage for all numbers from 0 to 50 of the horizontal series ; while from 60 to 110 of the same series the slide must be set so that its right hand vertical coincides with the right hand vertical of the stage ; in each case the horizontal lines of the stage and slide being adjnsted to coincide. By observing this rule the necessity of perfect accnracy in the position of the gnide lines upon the slides is done away with.

There are some objections, but not insuperable ones, to the moveable stage Indicator as above described. In the first place the stage as usually made has its motion too limited to correspond to the whole range of the Indicator, and secondly the guide lines ruled upon the stage for one object-glass may not answer for other powers on accomnt of slight inaccuracies of mounting.

The stages can donbtless be constructed to give as wide a range for motion as required, which will do away with the first mentioned objection. The second may be removed by placing an

Indicator upon the upper plate of the stage when the latter stands at $\frac{5}{7}\frac{0}{0}'$ and adjusting it so that when well centred *for the power employed* the line C F shall be parallel to the front edge of the stage. The slide being then placed upon the Indicator with its guide lines at $\frac{5}{4}\frac{0}{0}'$ or $\frac{5}{7}\frac{0}{0}'$ the remaining motions may be made with the screws in the usual manner and the numbers may be read off from the stage scales instead of the Indicator.

The above mentioned modifications are excellent for individual convenience; but for the general purposes of science, the comparable, transferable, reproducible Indicator, in its simplest form, must be preserved; and it is only in that form that it deserves the name, suggested by a friend, of the Universal Indicator.

As a proof of the utility and accuracy of the Indicator, and of its convenience as a means of scientific exchange, I may state that numerous mounted slides of minute recent and fossil Diatoms have been exchanged through the Post Office by Judge A. S. Johnson of Albany, and myself, and that each has found by the ordinary as well as modified forms of the Indicator all the shells however minute, fragmentary or previously unknown, which the other had recorded. Some of these objects were less than a $\frac{1}{1}\frac{1}{0}\frac{1}{0}\frac{1}{0}$th of an inch in diameter, and yet they were found without difficulty by means of the Indicator.

To determine whether different impressions of the Indicator when made on the same kind of paper were comparable, a set of objects was registered successively by seven different impressions made on enamelled cards some of which were arranged with the ordinary paper centre piece, and others with the central guide lines ruled upon glass. The numbers being recorded for the objects when well centred upon one of these Indicators, the slide was then transferred to each of the other Indicators and each object being brought into the field by its recorded numbers, the position was carefully adjusted so that the object should be well centred, and a record for each copy of the Indicator was thus made. On comparing the different numbers it was found that the coincidence was almost perfect, the difference never exceeding $\frac{1}{4}$ of one of the divisions of the Indicator, an amount which might be quadrupled before an object would be thrown out of the field of view of my $\frac{1}{2}$ inch objective.

The Indicator having been put to so many and such severe tests I feel no hesitation in recommending it as a means of scientific intercourse among observers, and as a means by which collections of microscopic objects may be registered, arranged, and catalogued; and an index to the whole so made that any particular specimen may be found at will either by the original observer or any one into whose hands the slides and accompanying register may at any time come.

The copy of the Indicator which accompanies this paper is not given for use with the microscope, as the kind of paper upon which it is printed is different from that used for the standard Indicator, and therefore in consequence of unequal shrinkage a slight deviation is produced. The Indicator for use with the microscope is printed upon enamelled cards, and the different impressions have been found to agree so closely with each other as well as with the original plate that no appreciable error is perceived.

I can not close this paper without expressing my warm thanks to Judge A. S. Johnson of the New York Court of Appeals, for his cordial sympathy and aid in testing the merits of the Indicator and for some excellent suggestions as to its best form for general use. I should also express my obligations to the engraver, J. E. Gavit, Esq, of Albany, who has spared no pains in making the steel plate from which the Indicator is printed as accurate as possible.



Fig 2

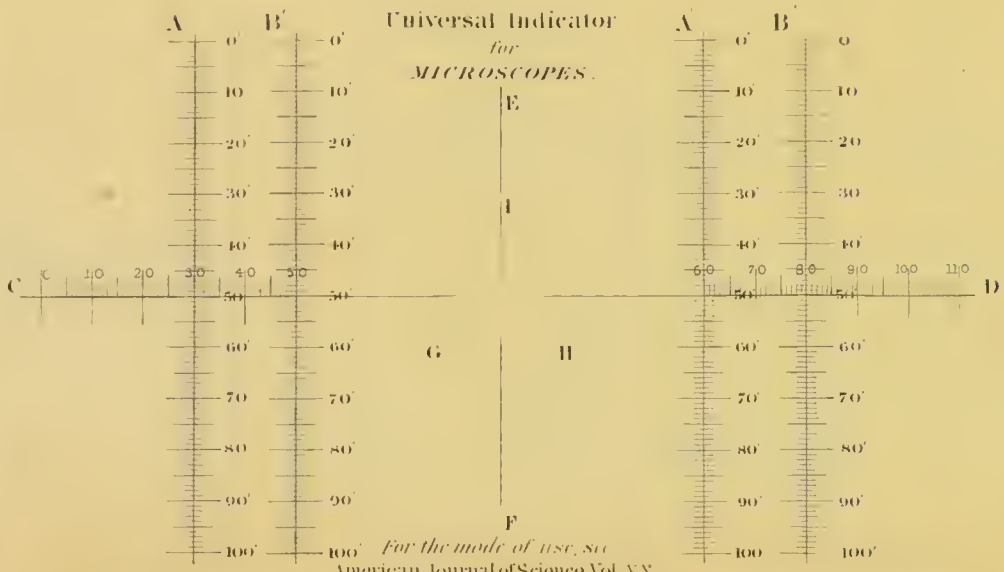

Universal Indicator
for
MICROSCOPES.
A
B
C
D
E
F
G
H
I
0
10
20
30
40
50
60
70
80
90
100
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
For the mode of use, see
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Fig 1